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Processing and displaying multibeam sidescan sonar data: visible, redundant, and overlapping beams

John A. Fawcett

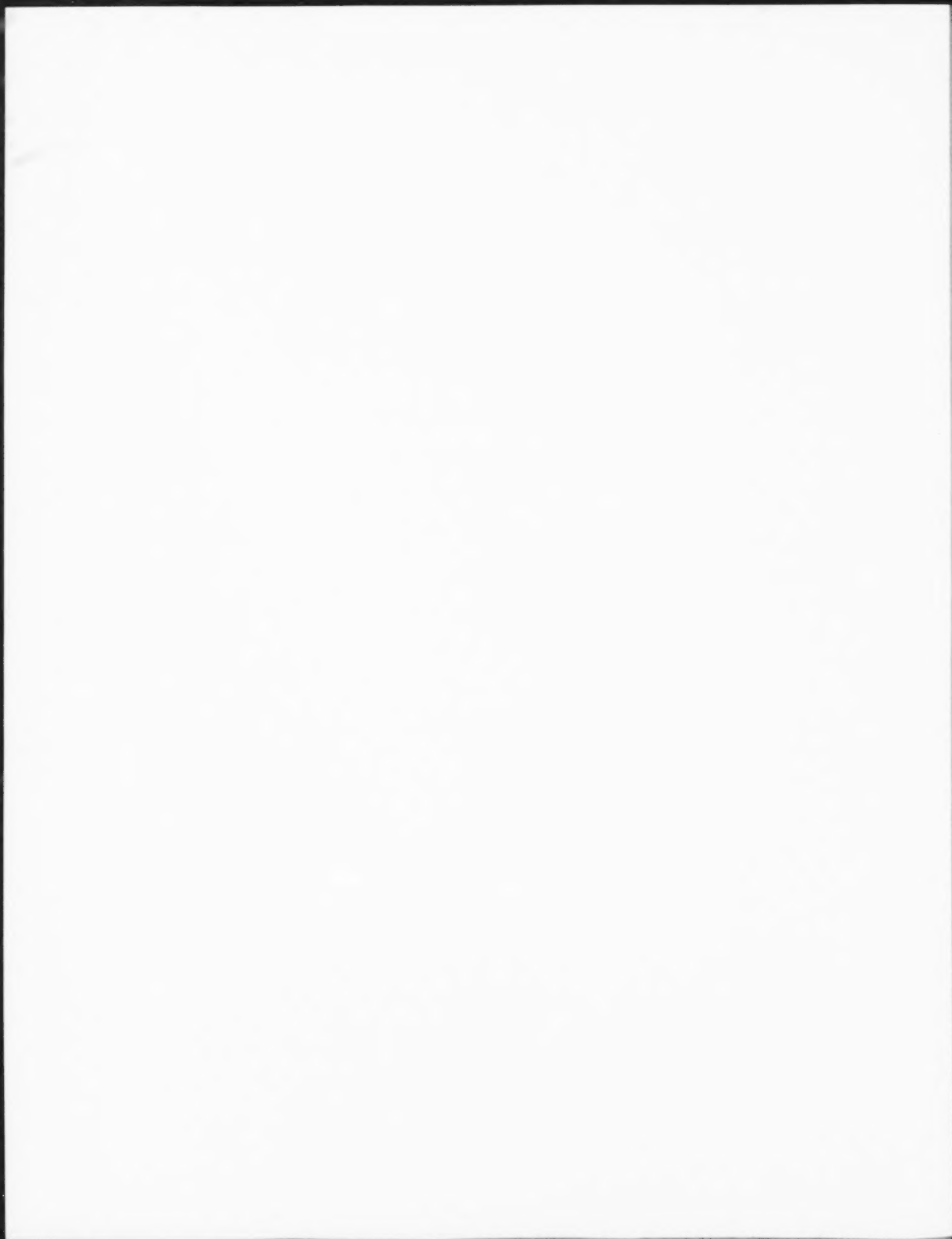
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Technical Memorandum

DRDC Atlantic TM 2002-003

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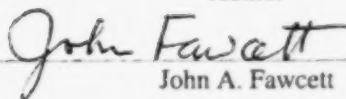
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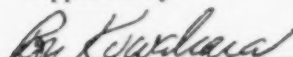
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Abstract

In this paper the processing and display of multibeam sidescan sonar data is discussed. In particular, for a multibeam system there is often a significantly redundant coverage of the seabed. The question arises as how to best utilise all this data in terms of image quality and subsequent processing (e.g. image segmentation, feature extraction, etc). A variety of options are explored with a particular set of data obtained with the DRDC -Atlantic Klein 5500 sidescan sonar.

Résumé

Dans cet article, nous discutons du traitement et de l'affichage des données obtenues par les sonars multifaisceaux à balayage latéral. Souvent, la couverture du fond marin par les systèmes multifaisceaux est fortement redondante. On peut se demander comment mieux exploiter toutes ces données pour améliorer la qualité de l'image et permettre un traitement ultérieur (p. ex. : la segmentation de l'image, l'extraction de caractéristiques, etc.). Nous explorons plusieurs possibilités en utilisant un ensemble précis de données recueillies avec le sonar à balayage latéral Klein 5000 du RDDC-Atlantique.

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Executive summary

Background:

Multibeam sidescan sonars produce a sequence of beam-blocks which map out the seabed. For a given ping rate these beam-blocks will often overlap each other providing a redundant coverage of the seabed. Some systems, in fact, adjust their ping-rate according to the ship speed in order to have some of the beams from each set overlap each other as exactly as possible. This is done so as to make the display of the data easier. However, if processed properly, including the redundant beams can provide improved image quality.

Principal Results:

It is shown that by using all beams, including the so-called redundant beams, in the sonar display can significantly reduce image-speckle and enhance the visibility of small features. Moreover, by increasing the ping-rate of the sonar over its typical speed-dependant value, images at a higher resolution can be formed.

Future Research:

More work on how to best collect, display, and utilize the information contained in all the beams of a multibeam sidescan sonar should be continued.

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Sommaire

Contexte : Pour faire la carte d'un fond marin, les sonars multifaisceaux à balayage latéral émettent des séquences de blocs d'impulsions réparties dans les différents faisceaux. Habituellement, pour une fréquence d'impulsion données, ces groupes d'impulsions se chevauchent ce qui résulte en une couverture redondante du fond marin. Pour diminuer la redondance de la couverture et faciliter l'affichage des données, certains systèmes ajustent la fréquence de l'émission des impulsions, en fonction de la vitesse du bateau. Cependant, on pourrait améliorer la qualité des images, avec un traitement tenant compte des données redondantes.

Résultats principaux : Nous montrons qu'en prenant en compte des données de tous les faisceaux, notamment les informations dites redondantes, on peut réduire le chatoiement de l'image de l'affichage sonar et accroître la visibilité des petites entités. Qui plus est, en augmentant la fréquence de l'émission des impulsions sonar à une valeur supérieure à la valeur déterminée par la vitesse, on pourra créer des images à plus forte résolution.

Recherche à venir : On devrait effectuer plus de travail sur les meilleures façons de saisir, d'afficher et d'utiliser les informations contenues dans tous les faisceaux des sonars multifaisceaux à balayage latéral.

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1. INTRODUCTION

In this paper we investigate different methods of pre-processing and displaying sidescan sonar imagery. In multibeam sidescan sonars such as the Klein 5500 sidescan sonar, the transducers' timeseries are beamformed to form a set of beams on either side. In the case of the Klein 5500 it is a set of 5 beams with an along-track resolution of 10 or 20 cm. The across-track resolution is determined by the bandwidth used and for the Klein 5500 is approximately 3.3 cm resolution. Thus the basic image pixel is not square.

Another important feature of the data is the concept of redundant beams; For fairly slow tow speeds, e.g. 4 knots, the beam block (the 5 beams) from one ping partially overlaps the previous beam block in coverage. Usually the ping rate of the sonar is adjusted according to the estimated tow speed in order that some of the beams will "exactly" overlap some of the previous set – by displaying only these beams which cover the seafloor without any redundancy, an intuitive visual display can be generated (see Fig.1). For example, the Klein sonar software labels a set (not unique) of such beams as "visible" beams and the others are often called "redundant". However, it is clear that there is additional information in the redundant beams, so the question arises how to best utilize this information and yet produce an useful display. Huff[1] has previously examined some aspects of the use of all the Klein 5500's beams.

There is also the question of whether to display the "raw" data or whether to display a geocoded version. The disadvantage of true geocoding is that one often wishes to preserve the orientation of a target relative to the towfish (for example, shadows should always lie starboard or port of the target highlight) However, one can do a "pseudo-geocoding" where the local mean heading of the towfish is defined as "north", resulting in an apparent north-going course, and only the variations of the heading about the mean and the translations of the towfish are used in the geocoding. As we shall see, this technique has the advantage of naturally combining all the beams (including redundant) in a natural fashion and accounting for any inter-ping towfish motion. An image built up from just the visible beams may have distortions in it due to, for example, pitch variations between pings (speed variations are approximately accounted for by varying the ping rate according to the estimated towfish speed) – "pseudo-geocoded" image should not have these distortions. This is particularly important for target-image classification where the estimated dimensions of the object may be crucial in its classification. Of course, the accuracy of the motion corrections used in this geocoding depends upon the accuracy (relative) of the navigational data and this is a difficult issue. Often the pitch and yaw of the towfish exhibit small, but quite rapid, variations and the optimal smoothing strategy is not clear. Although, we don't do this in this paper, it may be possible to use techniques, such as those used in [2], to try to allow the data itself to determine the motion corrections.

Finally, we note that it would seem that the optimal strategy, for the most information, would be to ping as fast as possible (but allowing for the sound to propagate out to range and back again). This will, in general, result in beams which have a significant amount of overlap and, in fact, the beams may overlap each other fractionally. As is shown in Figure 1, this is due to the translation of the towfish along its mean heading, but also there may be a "focussing"

effect due to the variations in the heading. This effect will be larger at longer cross-track ranges. In [3] it was shown that it was theoretically possible to obtain improved along-track resolution by appropriately processing overlapping beam data. An algorithm was given that determined the discrete two-dimensional reflectivity of the seabed in such a way as to optimize the agreement with the recorded beam time series and to satisfy smoothness constraints on the reflectivity function. A Fourier based method for deconvolving the beam pattern from the data to produce an enhanced image was presented in Reference 4 for single-beam sidescan sonar data.

In this paper, we will illustrate the above concepts using Klein 5500 sidescan sonar data obtained from surveys near Herring Cove, Halifax where a variety of targets were placed. In particular, we will consider a water-filled, steel-shelled cylinder, shown in Fig.2 (four of these cylinders were deployed). These cylinders are approximately 2 m in length and 0.5m in diameter. The sidescan sonar was towed past these cylinders using 100 m range-setting with a 20 cm along-track resolution, a 75m range-setting with 10 cm along-track resolution, and in one 100m/20cm run, a false manual speed was used with the sonar processor, in order that the sonar pinged at a faster rate than it normally would based upon the true towfish speed. During this trial, the Klein processor was applying a low-level de-speckling algorithm which complicates the interpretation of the results a little; in the future, we hope to repeat some of these experiments with this processing off.

Displays of the sidescan sonar image are generated using (a) the standard display technique of displaying only the "visible" beams (b) "pseudo-geocoding" all the beams (c) "pseudo-geocoding" all the beams, in the case of overlapping coverage, to produce an image at resolution smaller than the beam resolution (d) applying the iterative method of optimizing the image of (c).

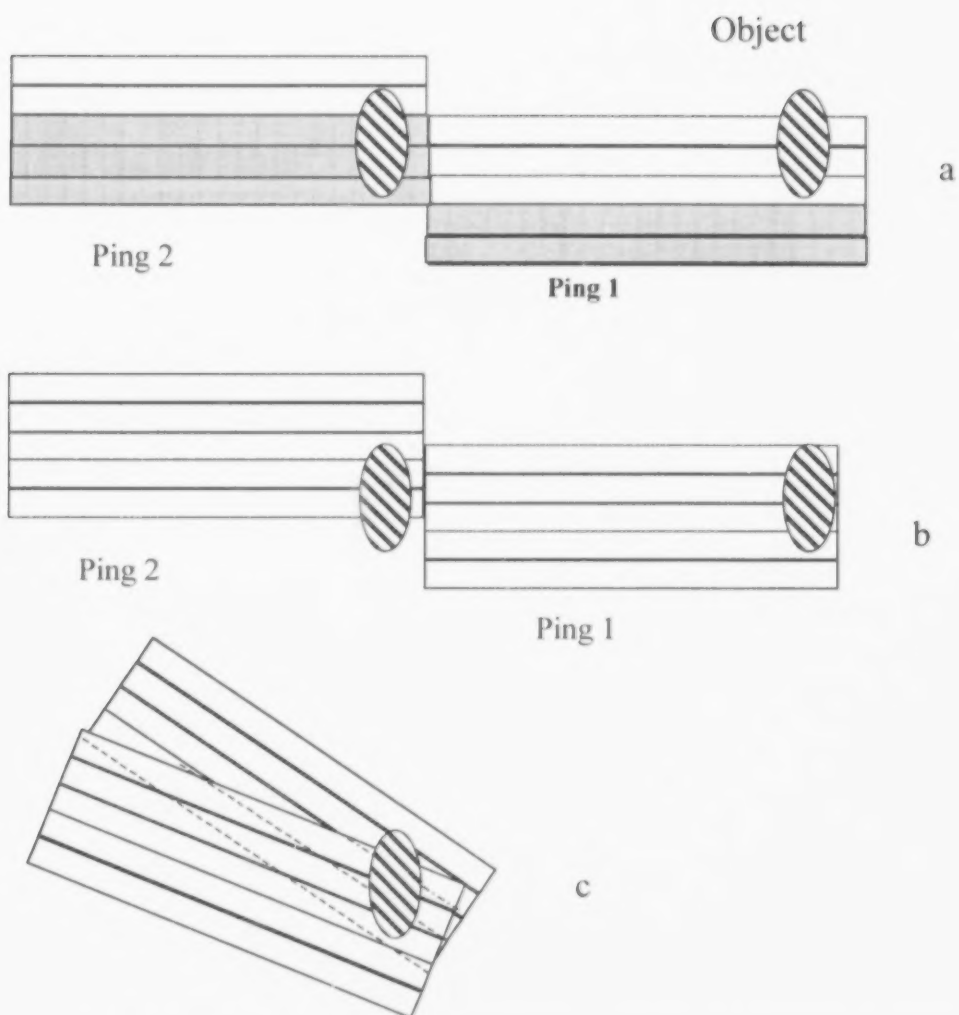


Figure 1 Two consecutive pings of 5 beams ensonifying an object. In (a) and (b) the beams sets have been displaced horizontally for clarity. (a) redundant beam coverage (a possible set of "visible" beams is shaded grey) (b) overlapping beam coverage (c) additional overlapping coverage due to the heading variation of the towfish

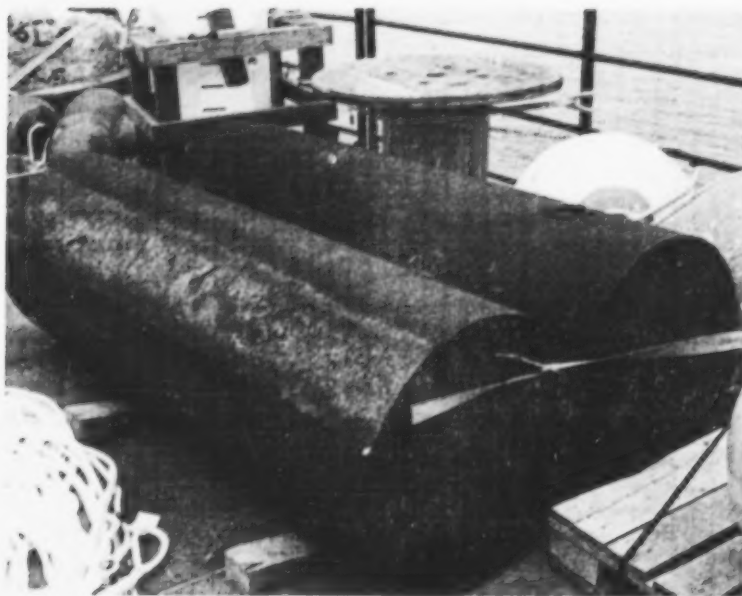


Figure 2 Two of the cylinders that were deployed

EXPERIMENTAL RESULTS

We first show a segment of raw sidescan imagery, for the 10 cm along-track resolution, with full time resolution and all beams. In this case the towfish was being towed at approximately 4 knots and at this speed, only 2 beams are required to yield a complete picture of the seabed. Here, where we show all 5 beams from each block, it is possible that beams from up to 3 beam blocks will intersect a given 10x10 cm square on the bottom. Thus the image below shows repeated imaging of the same area of the seabed, resulting in the striated appearance of the figure below. The primary object that is seen is the water-filled cylinder (highlight and then shadow). It is interesting to note the significant non-specular returns which occur at the one end of the cylinder – this occurred with the other 3 cylinders on the seabed as well and is probably due to internal reflections within these water-filled, thin-shelled cylinders. There is another noticeable object in the lower right-hand corner. There are also other smaller features; for example, note the indicated events. Due to the fact that these features are repeated in a few beams probably indicates that it is more than mere "speckle". We are showing these images at full time-resolution. Note how well the details of the "ringing" time series are resolved.

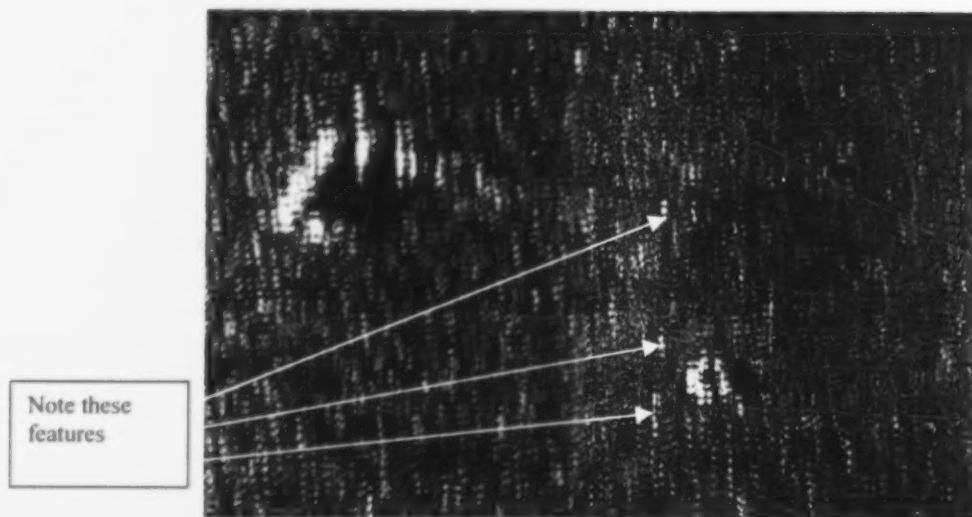


Figure 3 Raw data for 10 cm resolution, the box is approximately 10m vertically and 12m horizontally

One standard way to display the data of Fig.3 would be to (1) show just the "visible" beams and (2) perhaps square the pixels. In Fig. 4 below 2 sets of processed data are shown, the result of (a) using just the visible beams with the pixels approximately squared by taking the median of each set of 3 across-track points and (b) the result of using a pseudo-geocoding of all beams. In Fig. 5 the corresponding "zoom" areas about the cylinder are shown. As was expected, the result of using all beams is to suppress much of the speckle of the original figure and to enhance some small features; for example, the small features pointed out in Fig.3 are visible in Fig.5(b) and not in Fig.5(a) (although, this maybe partially due to the fact that for the image of Fig.5(a) we have median filtered (by a factor of 3) in the across-track direction). In order to "pseudo-geocode" the image, significant care was taken in smoothing the navigational data. In this geocoding process we use the average intensity value within the cell; we also tried using the median value but found little difference in the results.

Another use of the increased number of data points per cell on the seabed is that this data can be used to better estimate the statistical parameters of the data for each geocoded cell. In Fig. 6 the computed standard deviations of the data values that form each each geocode cell are shown. From this figure we can see that objects which give a highlight also show an enhanced standard deviation; this can be explained by the fact that as different beams look at the same object the reflection strength may change significantly due to slight changes in geometry. Also, there are some small features which are enhanced by this type of display. Areas of shadow have low standard deviations. It maybe that this information could be useful, in addition to the mean pixel values themselves, in segmentation algorithms.



Figure 4 (a) Standard visible beams display (b) "pseudo-geocoded" display. An 8-bit grayscale is used

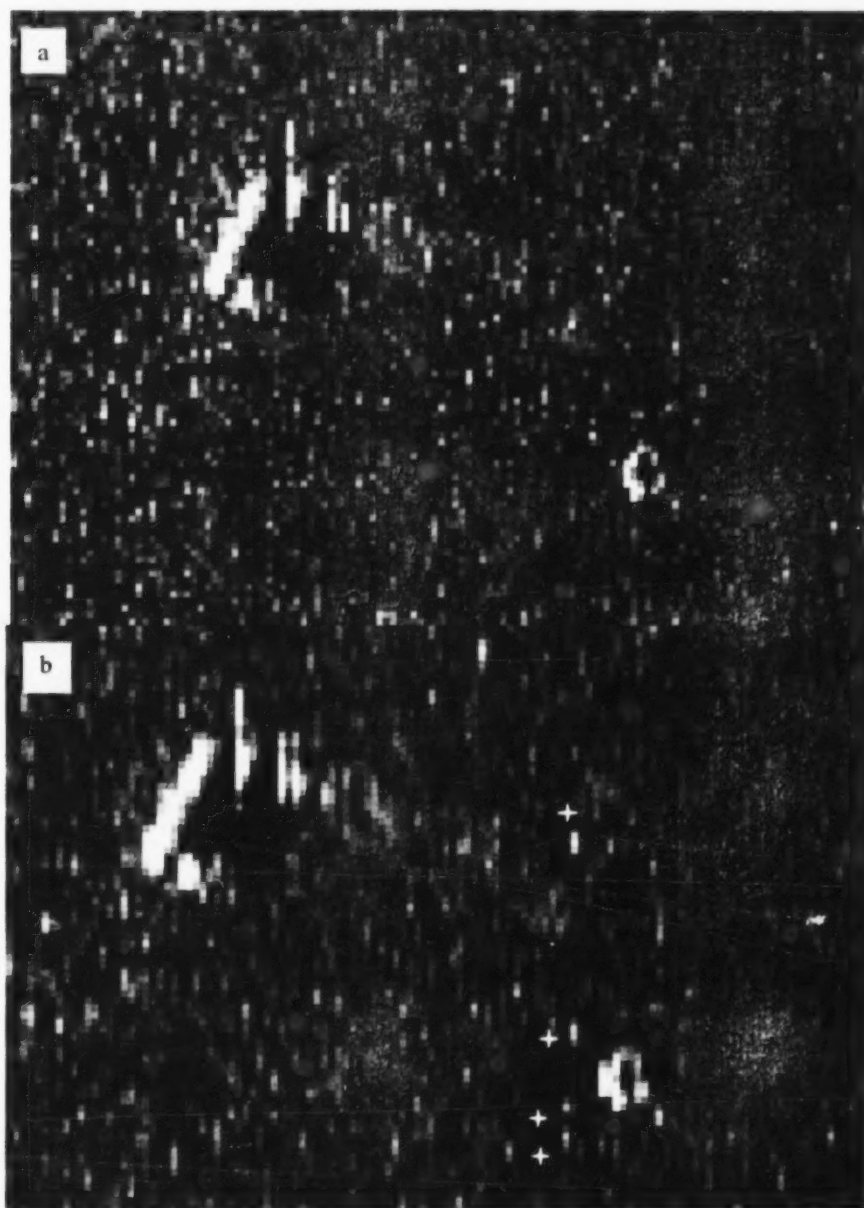


Figure 5 Zoom of images from Fig.4 – the stars in (b) indicate the positions of the indicated features in Fig.3. The two bottom stars correspond to the bottom most features in Fig.3.



Figure 6 *Standard deviation of image values in geocode cells for the image of Fig.4b*

Let us now consider a 20-cm resolution pass of the same target. Below we show the results of using the visible beams with a 6-fold decimation in time, forming approximately square pixels and also the image formed by the "pseudo-geocoding" process. The first thing that we note is the significant degradation in the image-resolution in going from the Klein 10-cm resolution to its 20-cm resolution. Second, we note that as in the previous case that the use of all beams has significantly reduced the amount of speckle. The small object in the lower right is simply a small rectangle and no longer has the detailed shape seen in the 10-cm case.

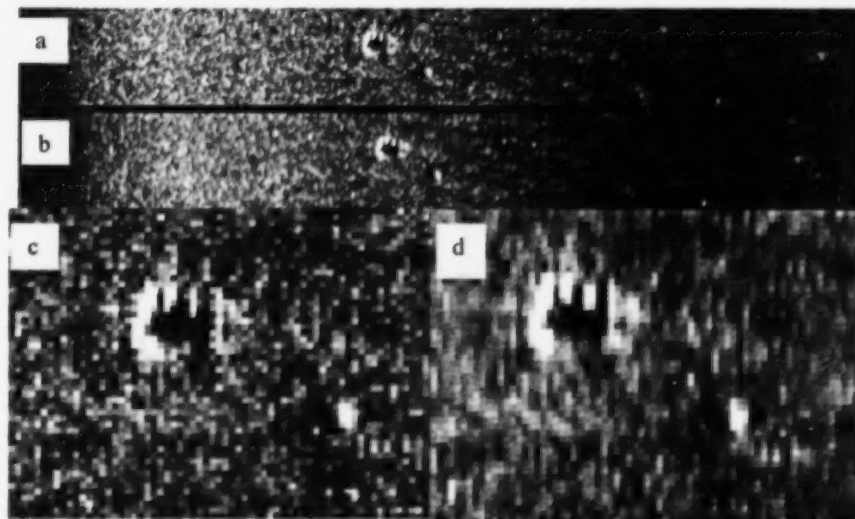


Figure 7 (a) Standard visible beams display and (b) "pseudo-geocoded: results for 20 cm beam along-track resolution and 20 cm geocoded resolution. The corresponding zooms about the cylinder are shown in (c) and (d)

We also show the computed standard deviation for this imagery below in Fig.8. As in the previous case there are high standard deviations in the highlight regions and low standard deviations in the shadow regions. There are also some small features which seem more apparent in this image.

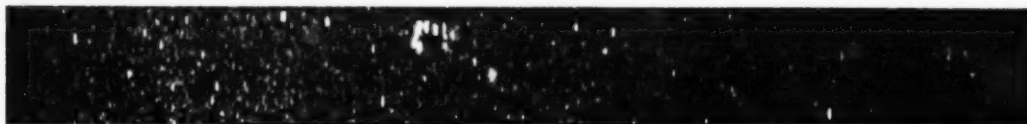


Figure 8 Standard deviation of the data used in geocoding process for image of Fig.7b

Thus far, the data has corresponded to the case where consecutive beams overlap each other almost exactly; for example, beams 4 and 5 from one ping may lay on top of beams 1 and 2 from the previous ping (although, as mentioned previously this will not be exact due to the pitch, yaw, changing speed, etc). We have seen that averaging these pings together does suppress speckle and enhance some features, but, in a sense there is no new information about the seabed. It was shown in Ref.1 that by having, for example, a fractional overlap of $\frac{1}{2}$ for successive beams that one could, in principle, reconstruct a profile with a resolution half that of the beamwidth. However, it was also shown in that reference that this is inherently a ill-posed problem and that some smoothness constraints on the solution need to be invoked.

For the data example below, the Klein 5500 sonar processor had a manual speed set which was higher (about 1.5 times) than the actual speed of the towfish; thus the ping rate was, in fact, incorrect to yield exactly overlapping beams, but yielded fractionally overlapping beams. Also, an analysis indicated that the variation of the towfish heading and pitch caused additional overlap effects.

Below, a section of this data, with all beams is shown in Fig.9. The beamwidth here is 20 cm. Because of the large amount of overlap between successive beam blocks the image is very "confused". However, as before we will use a geocoding process to image the data. In Fig.10 we show the beam/time centres for all the beams computed for the section of the data corresponding to the area of the cylinder. As can be seen, the along-track distances between beam centres are irregular, but are, in almost all cases, less than 10 cm.

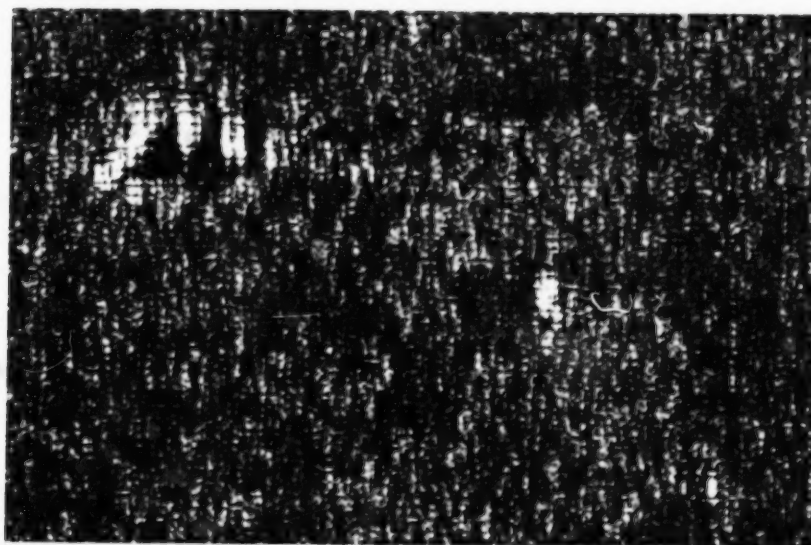


Figure 9 Raw data using 20-cm beams but an excessive ping rate

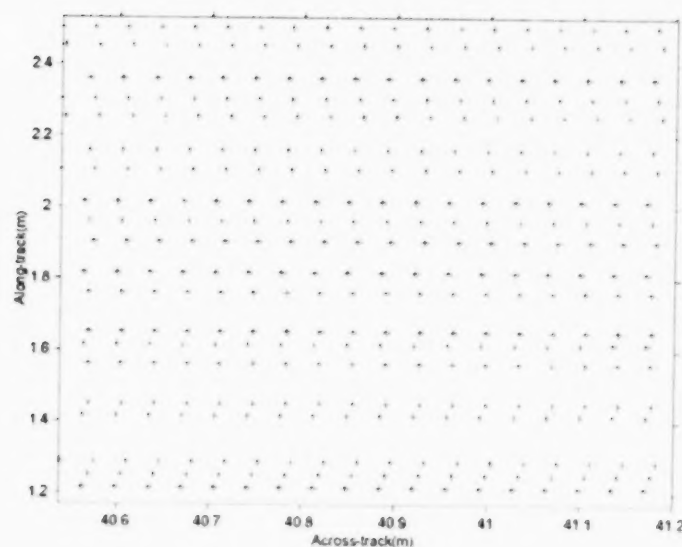


Figure 10 Computed along-track positions of beam-centres for a section of the image (the across-track centres have been subsampled). As can be seen the along-track beam spacing is usually less than 10 cm and in some cases is as small as 5 cm. This complicated pattern is due to altitude, heading and pitch variation

In Fig.11 below the resulting geocoded swath at 10 cm resolution is shown as well as the zoom region around the objects. Here because of the overlap from many beams it is expected that there will be some blurring of the features in the image; however, despite this effect, we can see that the additional pings have yield better image definition of the objects over the 20-cm along-track case (see Fig. 6). The standard deviation plot is shown in Fig.12.

In an earlier paper [3] we described a non-linear optimization scheme for the reconstruction of reflectivity profiles from overlapping beam data. This algorithm seeks a two-dimensional reflectivity matrix which when convolved with the beampatterns yields the best match with the observed data, while retaining a certain smoothness. The smoothness constraint was used to avoid solutions which were highly oscillatory. In particular, the cost functional is a combination of the error between the predicted and the observed data and a smoothness term. As in [1] this smoothness function is the sum of the square roots of the differences between neighbouring points; this particular smoothness measure is chosen to "encourage" a small number of larger changes in the reflectivity profile instead of many small changes. In this paper, the underlying seabed model is taken to consist of a set of 10 x 10 cm spatial cells. A matrix $\mathbf{R}$ is computed which relates the data $\mathbf{d}$ to the cell values $\mathbf{C}$. Thus the cost functional is given by

$$F(\mathbf{C}) = \|\mathbf{d} - \mathbf{RC}\| + \lambda \sum_{ij} \sqrt{|C_{i+1,j} - C_{i,j}|} + \sqrt{|C_{i-1,j} - C_{i,j}|} + \sqrt{|C_{i,j+1} - C_{i,j}|} + \sqrt{|C_{i,j-1} - C_{i,j}|} \quad (1)$$

The matrix $\mathbf{R}$ is computed numerically by determining the amount that each pixel of $\mathbf{C}$ contributes to each beam/time cell of the data. The matrix $\mathbf{R}$ is large (the number of data points (beams x time points per beam) X the number of geocoded spatial cells) but sparse, so that for each data point we simply keep a set of pointers to the corresponding geocode cells and the relative weightings of each cell. These weightings are computed numerically by subdividing each beam/time cell into smaller beam/time divisions and computing the nearest geocoded cell that these smaller divisions correspond to. As was discussed in [1] the standard geocoded solution can be obtained simply by forming $\mathbf{R}^T \mathbf{d}$. Using this as a starting solution we use a simple iterative Monte-Carlo method to reduce the cost-functional of (1) with $\lambda = 50$ and 20 (the difference in λ is due to the differences in the value of the first term in Eq.(1)).

We use this algorithm on very small mugshots: (1) containing just the cylinder (2) the small object of the upper right hand corner. In Figs. 13 and 14 below we show the standard geocoded image (using the transpose of $\mathbf{R}$) and the result after 1024 iterations of the non-linear algorithm.

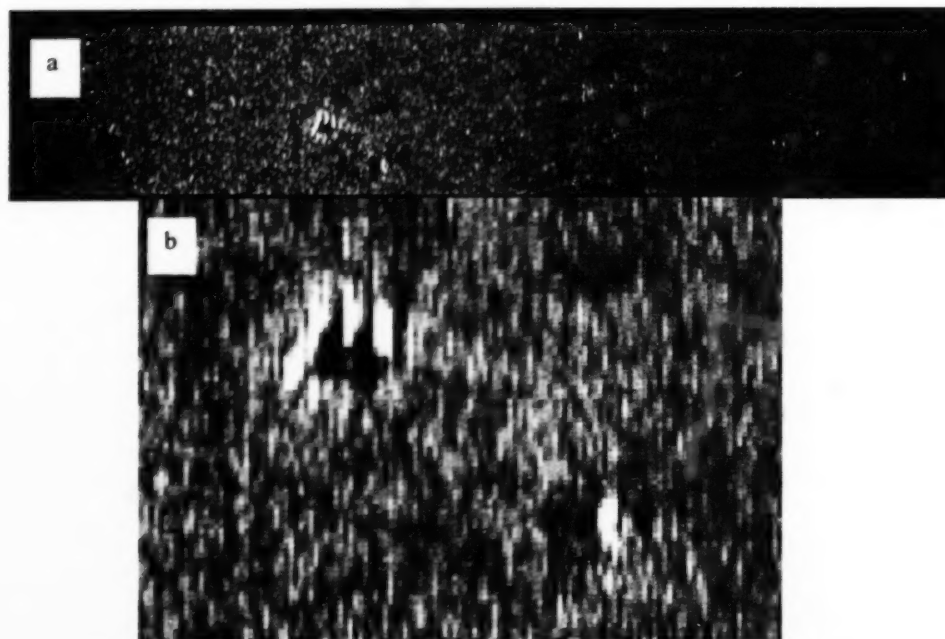


Figure 11 (a) the pseudo-geocoded image using 20-cm beam data but geocoded to 10 cm resolution. Representative beam centres for this data were shown in Fig.10 (b) a zoom around the cylinder

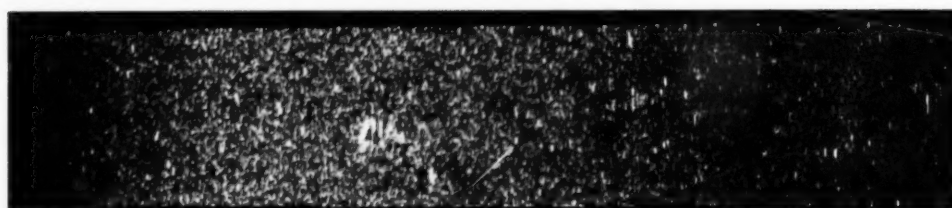


Figure 12 Standard deviation of data within geocode cells of Fig.11a

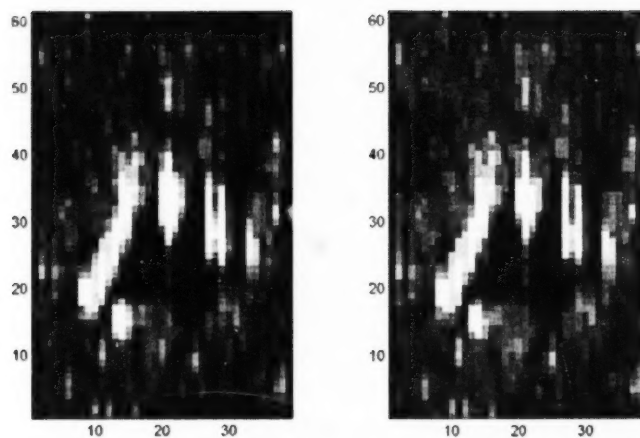


Figure 13 Geocoded and processed image; The left image is formed by using the transpose of the R matrix in Eq.(1), this serves as the starting image in the non-linear iterative method, the final result after the iterations is shown on the right

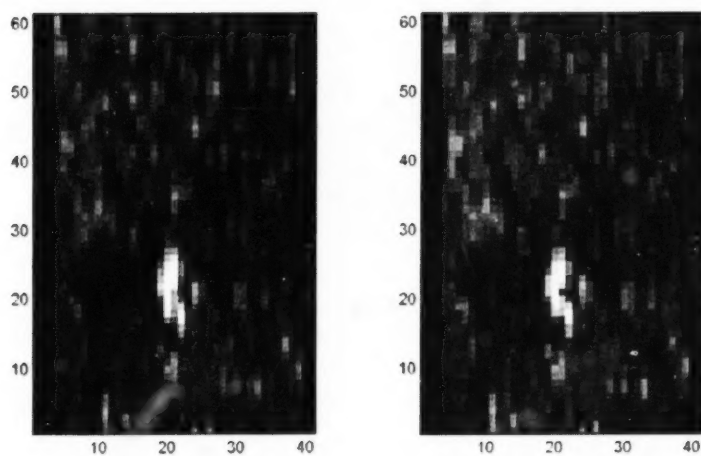


Figure 14 Geocoded and processed image as in Fig.13

The iterative algorithm tends to "sharpen" the standard geocoded-image in a manner which is consistent with the data. For the above figure, the algorithm, in fact, decreased the difference between the observed and predicted data by about 7% over the initial value and the smoothness of the solution as measured by the second term in (1) is also improved. It is, of course, possible to use more iterations of the algorithm or one could use some other optimization scheme such as simulated annealing or genetic algorithms, etc to perform the optimization. However, the results of Figures 13 and 14 are representative of the result of the algorithm.

SUMMARY

In this paper we have shown the advantage of utilizing all the beam information (i.e., including the redundant beams). The amount of speckle in the image can be reduced and some features enhanced. It is anticipated that because of the reduced speckle that highlight/shadow segmentation routines should be able to work better. In addition, because of the larger amount of data points per cell, a better estimation of statistical quantities such as the cell standard deviation etc. can be obtained and this information might also be useful in detection and segmentation algorithms.

Although the ping-rate of the sonar is adjusted so as to attempt to make the beams overlap an integral amount, this in practice, does not happen due to the speed, pitch, and heading variations of the towfish. We chose to combine the intensities of the beams by using a geocoding process, in an attempt to "focus" the energy as much as possible. Carrying this concept further, the speed of the towfish was manually set to a false value in attempt to have a higher ping rate and beams with fractional overlap. In this case, the only logical way to combine the energy is through a geocoding process. In the experiment described in this paper, using the overly-fast ping rate, the beams had a 20 cm resolution but the beam-centre separation was much smaller; this allowed us to produce a geocoded image of 10-cm resolution. However, this process inherently averages over features. We used an algebraic, iterative method described in a previous paper [3] to sharpen the images, in a manner which is consistent with the actual data.

One problem which still exists is the inaccuracies in the knowledge of the detailed towfish motion, even with the various sensors on the towfish. These leads to inaccuracies in the geocoded image. This will be a particular problem if one wishes to exploit the use of overlapping beams where precise positioning of the beams on the seafloor is important. It may be possible to use the sonar data itself to yield information about the towfish motion.

It is hoped in the future to continue research into optimal data collection and processing to improve the informational content of the sidescan sonar images.

References

1. L. Huff, *Evaluating beam utilization in the Klein system 5000 side scan sonar* in Proceedings of Shallow Survey'99: International Conference on High Resolution Surveys in Shallow Water, October 18-20, 1999, Sydney, Australia, edited by Roger Neill, DSTO Australia (1999).
2. D.T. Cobra, A.V. Oppenheim and J.S. Staffe, *Geometric distortions in Sidescan Sonar Images: A Procedure for Their Estimation and Correction*, IEEE Journal of Oceanic Engineering, Vol. 17, pp. 252-268, July 1992.
3. J. Fawcett, *Geocoding sidescan sonar data - an inverse problem*, presented at Oceans 2000, Providence, September 2000
4. C. Fox, F. Jones and Tai Kwan Lau, *Constrained iterative deconvolution applied to SeaMARC I Sidescan Sonar Imagery*, IEEE Journal of Oceanic Engineering, Vol. 15, pp. 24-31, January 1990.

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In this paper the processing and display of multibeam sidescan sonar data is discussed. In particular, for a multibeam system there is often a significantly redundant coverage of the seabed. The question arises as how to best utilise all this data in terms of image quality and subsequent processing (e.g. image segmentation, feature extraction, etc). A variety of options are explored with a particular set of data obtained with the DREA Klein 5500 sidescan sonar.

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Sidescan sonar, geocode, resolution

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